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A field experiment was conducted in military warehouses in California to determine the effectiveness of pheromone-baited traps in capturing Trogoderma. Greater Trogoderma activity seems to occur near exterior walls with doors as suggested in the analysis of the Tracy Warehouse data. This effect could not be shown in the Lathrop warehouse. Also, statistically significant differences could not be shown for the effect of trap height in either warehouse even though trap counts were highest in floor traps. Pest management personnel found the traps easy to assemble, handle, and use.

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DETECTION AND CONTROL OF INSECTS IN STORED FOOD

PART I – THE EFFECT OF PHEROMONE-BAITED TRAPS AND THEIR PLACEMENT ON THE NUMBER OF TROGODERMA SPECIES CAPTURED

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PREFACE

The work reported herein was done under a transfer of funds to the USDA Stored Product and Household Insects Laboratory, Madison, Wisconsin in cooperation with the Food Packaging and Processing Group, Food Engineering Laboratory, US Army Natick Research and Development Laboratories, Natick, Massachusetts under Project Number 1L162724AH99BE.

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INTRODUCTION

Pheromone traps are sensitive tools that can be used for detection and possibly control of stored product insects in the various military storage facilities for subsistence. Under laboratory conditions and under limited field testing, these traps show an excellent potential for a new approach to insect control problems in the military. The techniques, however, must be carefully refined so that precise assessments can be made with regard to kind and number of insects in military warehouses and the practical use of the traps by military pest management personnel.

Following the evaluation of attractant-baited traps under laboratory conditions, field testing in military warehouses must be done in order to determine the usefulness of these traps as a practical pest-management tool. Important factors to be considered must include: (1) the ability to detect certain insects at lower population densities than could be achieved by conventional inspection techniques, (2) cost-effectiveness, and (3) acceptance by military pest management personnel. The objective of this investigation was to determine the placement and effect of pheromone-baited traps on the number of **Trogoderma** species captured in military warehouses.

Two separate experiments were conducted, one in the Sharpe Army Depot, Lathrop, California and the other in Tracy, California.

MATERIALS AND METHODS

Traps were placed in two separate sections in each warehouse. The traps were divided into pheromone-baited traps and control traps. Further classification included the general location in the warehouse and whether or not they were placed on the warehouse floor or hung on a bracket about 5 feet above the floor.

Randomized block design was intended for each experiment with pheromone and height factors nested within position, that is, similar to a simple split plot design. This design was used for the Tracy warehouse but not for the Lathrop facility because of the difficulties in trap placement. Four position categories were used within the warehouses: interior columns, interior walls, exterior walls with doors, and corners. Within each position category all possible locations were chosen at random. The locations were subject to the constraints that no more than eight pheromone traps were used in a particular section and that no two traps were within 48 feet of each other. This constraint created some imbalance in the experimental design because some position categories had fewer locations from which to choose; for example, there were only two positions that were considered corners in section 2 of the Lathrop warehouse. The constraints placed upon the number of traps and their proximity to each other were necessary because of our concern for introducing too much pheromone into the air. This

excess could cause the insects to become confused and unable to follow pheromone trails to appropriate traps. Traps in the column category underwent a further randomization for direction or orientation. The entire randomization procedure was repeated for each tested section of the warehouses.

Traps were set out according to the randomization scheme near the end of August 1979, in both warehouses. Traps were examined daily for the first four days and then on a weekly basis for one month. The original traps were replaced with fresh traps on September 19 and were then examined weekly for the next four weeks. All trapped insects were placed in vials, labeled, and sent to the Madison Laboratory for identification.

RESULTS AND DISCUSSION

The Tracy warehouse seems remarkably free of **Trogoderma**. Over the two-month test period, only 24 **Trogoderma** and ten other insects were captured. Three traps, #15, #16 and #24, accounted for 16 of the 24 **Trogoderma** captured. The Lathrop warehouse data indicated a possible source of **Trogoderma** in section 2 near traps #3 and #11. Trap #15 in section 4 of the same warehouse captured more **Trogoderma** than any trap in the experiments. The capture record is summarized in Table 1.

Overall, the data indicated that pheromone-baited traps were effective in capturing **Trogoderma**. The data show a decline in the number of insects trapped near the end of the two-month study period, probably caused by a drop in the ambient warehouse temperature during August through October. The following statistical analysis is based on totals of **Trogoderma** captured during each month of the two months test period. However, the period 8/20 to 9/19 is emphasized since more insects were trapped during that time (see Tables 2 and 3).

STATISTICAL ANALYSIS OF DATA

A. Tracy Warehouse

A computer program was used to generate a table of means and an analysis of variance table for the Tracy warehouse data. Experimental effects were assumed to be fixed and the response was defined as $x + 1$ where x is the count of **Trogoderma** trapped during the period 8/20 to 9/19. The analysis of variance suggested that position of the traps in the warehouse is significant, for example, traps near the exterior walls accounted for most of the captured **Trogoderma** (see Table 4). The number of adult beetled captured in the pheromone-baited traps was significantly different than the number captured by the control traps. Both results are reflected in the table of means (Table 5), which is in the square root scale. However, these data were insufficient to judge the effectiveness of traps placed on the floor versus traps placed eight feet above the floor level.

B. Lathrop Warehouse

The planned analysis of variance for the data from this warehouse was not possible because of our inability to distribute the traps in the same patterns as in the Tracy warehouse. An approximate analysis was used by employing regression techniques to determine the presence or absence of experimental effects. This approach provided some idea of the relative importance of the effects of trap position, pheromone baiting, and response to the traps with regard to distance of traps above the floor.

Table 6 contains the T-ratios of the coefficients of the regression model used to fit the transformed data $x + 1$. This analysis revealed that the ratio for variable X6 (which is the variable for the presence or absence of pheromone) was highly significant ($P = < 0.001$). The other coefficients were not significant but we did consider their relative size. The coefficients of x3, x4, and x5 were related to the position of the trap. The air/floor variable, viz., the coefficient for x2, suggested that position was more important than height in explaining the number of **Trogoderma** adults captured in the various traps and trap arrangements in the Lathrop warehouse.

The greater number of **Trogoderma** caught in pheromone-baited floor traps versus the baited aerial traps would seem to indicate the significance of height in trap placement. However, there were two complicating factors in the analysis, viz., two large values for pheromone-baited floor traps were obtained from trap #15 in section 4 and trap #11 in section 2, and the fact that the large number of traps in which no **Trogoderma** were captured tends to exaggerate the effects of traps with large capture values.

CONCLUSIONS

The results indicate that the pheromone-baited traps are effective in capturing **Trogoderma** in military warehouses. More adult beetles were trapped near the exterior walls with doors than in any other location. This relationship was not true, however, for the Lathrop warehouse. Significant differences could not be shown with regard to the effect of trap height in either warehouse.

Pest management personnel at both locations found the traps easy to assemble, handle, and use in the various sections of the warehouse.

RECOMMENDATIONS

It is recommended that further field testing with statistically sensitive trap placement schemes be done in order to obtain a more precise evaluation of the response of **Trogoderma** beetles to pheromone traps in military warehouses.

Table 1. Capture Record for the 1979 California Warehouse Study

Warehouse	Section #	Time Period	# Trogoderma	# Other
Lathrop	2	8/20–9/19	43	2
	2	9/25–10/24	3	0
	4	8/20–9/19	17	4
	4	9/25–10/24	17	1
Tracy	2	8/20–9/19	15	6
	2	9/25–10/24	1	0
	3	8/20–9/19	7	5
	3	9/25–10/24	1	0

Note: No Trogoderma were caught by control traps in either warehouse through the test period.

Table 2. Summary for the Lathrop Warehouse Capture Records of Pheromone-Baited Traps (8/20–9/19)

	Section 2		Section 4	
	Floor	Air	Floor	Air
Column	18	0	1	1
Wall (Inside)	11	1	–	0
Corner	3	–	5	–
Outside Wall/ Door Area	7	3	21, 1	6, 6

Note: There are two traps in the outside category in section 4. Blanks indicate no trap of that type was set out.

Table 3. Summary for the Tracy Warehouse, Capture Records of Pheromone-Baited Traps (8/20–9/19)

	Section 2		Section 3	
	Floor	Air	Floor	Air
Column	1	0	0	0
Wall (Inside)	0	1	0	1
Corner	5	0	0	1
Outside Wall/ Door Area	2	6	1	5

Table 4. Analysis of Variance for the Tracy Warehouse Study

	Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
	Mean	47.85844	1	47.85844	1950.90	0.000
	Block	0.14824	1	0.14824	6.04	0.091
	Position	0.97910	3	0.32637	13.30	0.031
1	Error	0.07359	3	0.02453		
	Height	0.03878	1	0.03878	0.38	0.582
	Height/Block	0.14933	1	0.14933	1.46	0.314
	Height/Position	0.57922	3	0.19307	1.88	0.308
2	Error	0.30746	3	0.10249		
	Pheromone	1.59044	1	1.59044	64.83	0.004
	Pheromone/Block	0.14824	1	0.14824	6.04	0.091
	Pheromone/Position	0.97910	3	0.32637	13.30	0.031
3	Error	0.07359	3	0.02453		
	Height/Pheromone	0.03878	1	0.03878	0.38	0.582
	Height/Pheromone/Block	0.14933	1	0.14933	1.46	0.314
	Height/Pheromone/Position	0.57922	3	0.19307	1.88	0.308
4	Error	0.30746	3	0.10249		

Table 5. Means Derived from the Analysis of Variance for the Tracy Warehouse

Cell Means for 1st Dependent Variable

Block = Position =	Tracy 2 Column	Tracy 2 Wall	Tracy 2 Corner	Tracy 2 Outside
Pheromone/Floor	1.41400	1.00000	2.45000	1.73200
Control/Floor	1.00000	1.00000	1.00000	1.00000
Pheromone/Aerial	1.00000	1.41400	1.00000	1.00000
Control/Aerial	1.00000	1.00000	1.00000	1.00000
Marginal	1.10350	1.10350	1.36250	1.59450
Count	1	1	1	1

	Tracy 3 Column	Tracy 3 Wall	Tracy 3 Corner	Tracy 3 Outside
Pheromone/Floor	1.00000	1.00000	1.00000	1.41400
Control/Floor	1.00000	1.00000	1.00000	1.00000
Pheromone/Aerial	1.00000	1.41400	1.41400	2.23600
Control/Aerial	1.00000	1.00000	1.00000	1.00000
Marginal	1.00000	1.10350	1.10350	1.41250
Count	1	1	1	1

Table 6. T-Ratios for Regression Model — Lathrop Warehouse Data

Variables	Column	Coefficient	St. Dev. of Coef.	T-Ratio = Coef./S.D.
	—	1.0116	0.3500	2.89
X1	C2	0.0620	0.2919	0.21
X2	C3	0.2345	0.4241	0.55
X3	C4	–0.6098	0.4982	–1.22
X4	C5	–0.6098	0.4982	–1.22
X5	C6	–0.3355	0.4982	–0.67
X6	C7	1.3414	0.2826	4.75
X7	C8	0.6042	0.7033	0.86
X8	C9	0.8630	0.8206	1.05

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